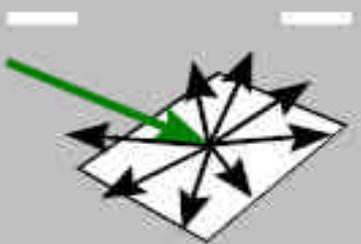


# Striping Retroreflectivity in Alaska

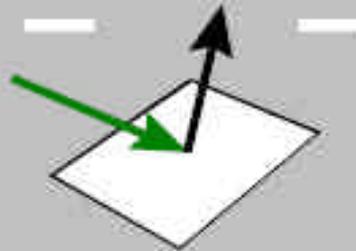
Clint Adler  
Research  
Engineer



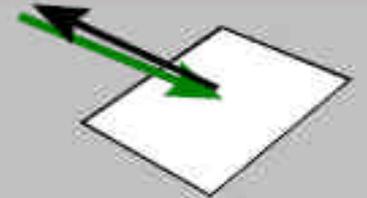
# Reflectors



**Diffuse  
reflector**



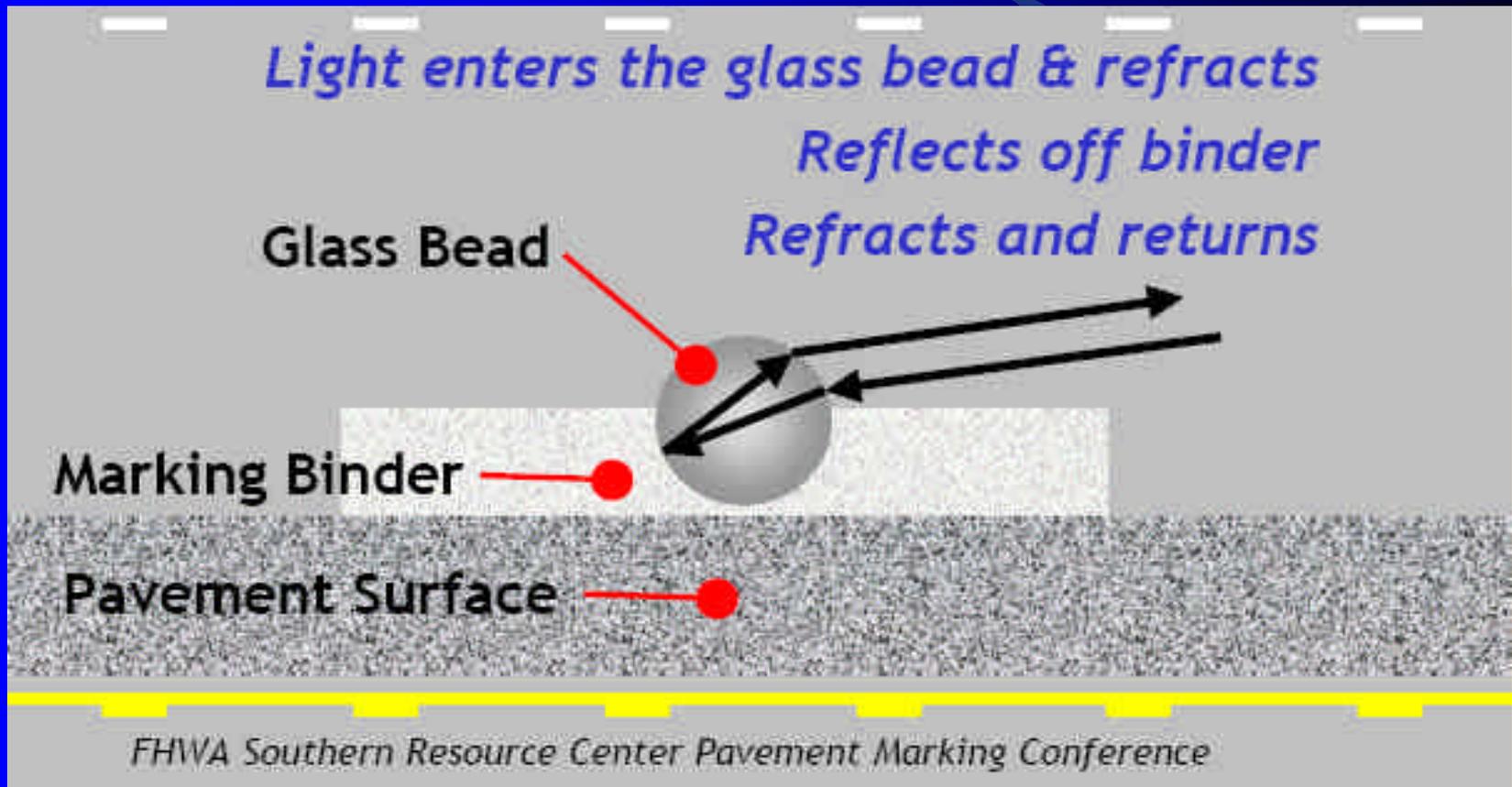
**Specular  
reflector**



**Retro-  
reflector**

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# Striping Retroreflectivity



# Why do we need retroreflectivity?

- “Based on estimates of vehicle miles traveled, the overall nighttime crash rate is approximately 1.6 times that of the daytime rate, while the fatal crash rate is three to four times greater at night.”
- “Factoring out alcohol-related crashes, the nighttime fatal crash rate is still nearly twice that of daytime. Although other human factor issues, such as fatigue, may account for some of the increased risk, it appears reasonable that visibility (or lack thereof) also contributes to nighttime crashes.”

<http://www.tfhrc.gov/pubrds/03jan/05.htm>

# Pavement Marking Retroreflectivity

- Retroreflectivity is the most important performance criteria for Pavement Markings in non-illuminated areas.
  - Vital for nighttime striping visibility

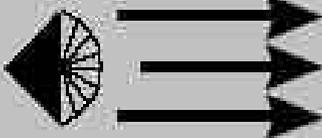
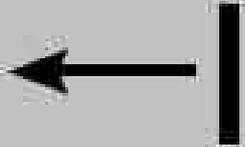
# Pavement Marking Visibility

- Daytime Visibility
  - Color
  - Contrast
- Nighttime Visibility
  - Color
  - Contrast
  - Location (left vs right)
  - Retroreflectivity



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# Photometric Terminology

Photometric Term (condition)	Concept	Measures
<b>Luminous Intensity</b> (light source)		candela (cd)
<b>Illuminance</b> (light falling on a source)		lux
<b>Luminance</b> (light coming from a surface)		$\text{cd/m}^2$

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# CONTRAST



# How much retroreflectivity is enough?

- No established criteria yet
- Depends upon many human factors
  - Age
  - Alertness
- Generally accepted minimum
  - 100 millicandellas/m<sup>2</sup>\*lux
  - Based on European 30 meter geometry

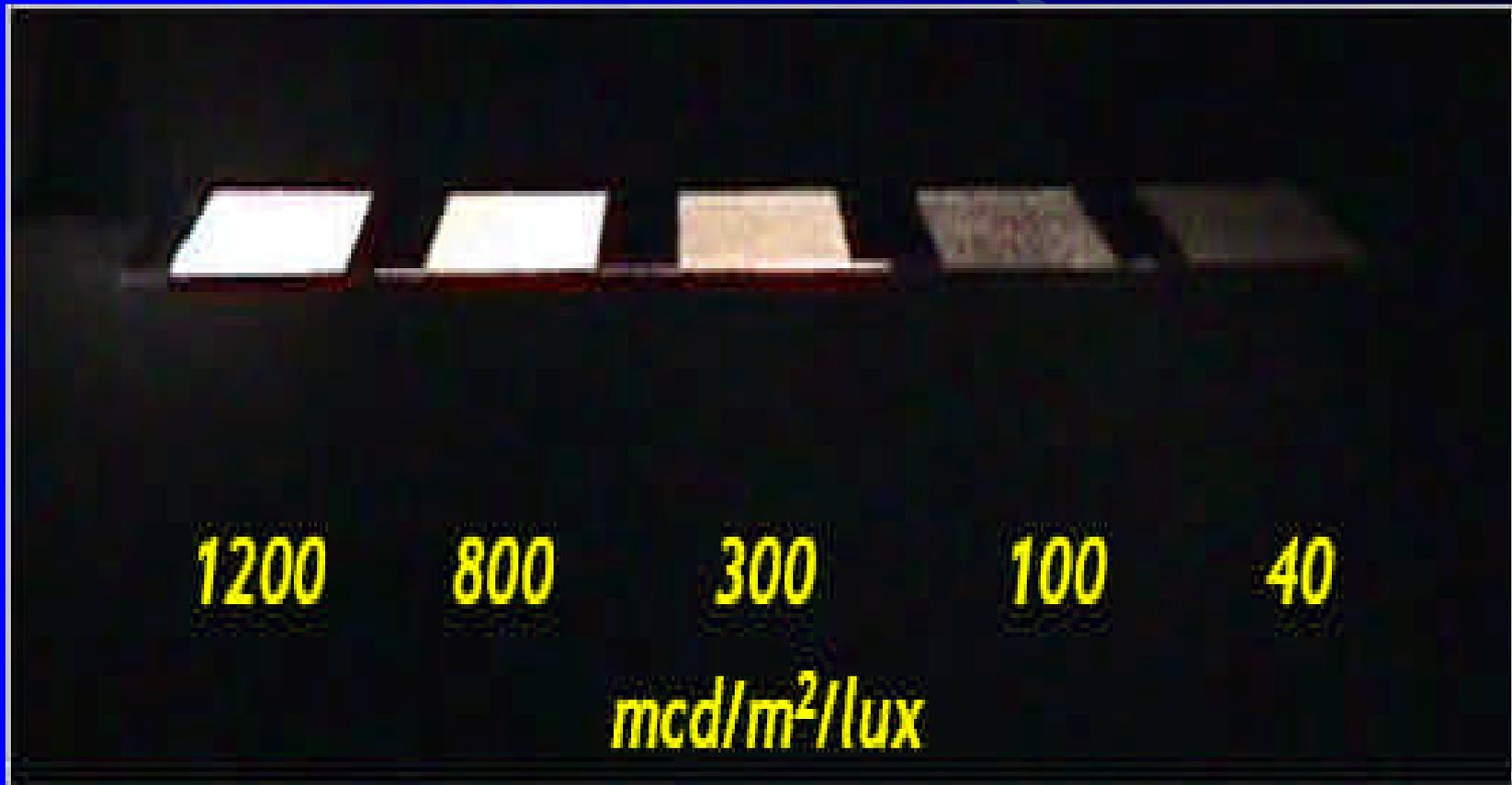
# Driver Luminance Needs

Starting at age 20, the amount of light needed to see doubles every 13 years



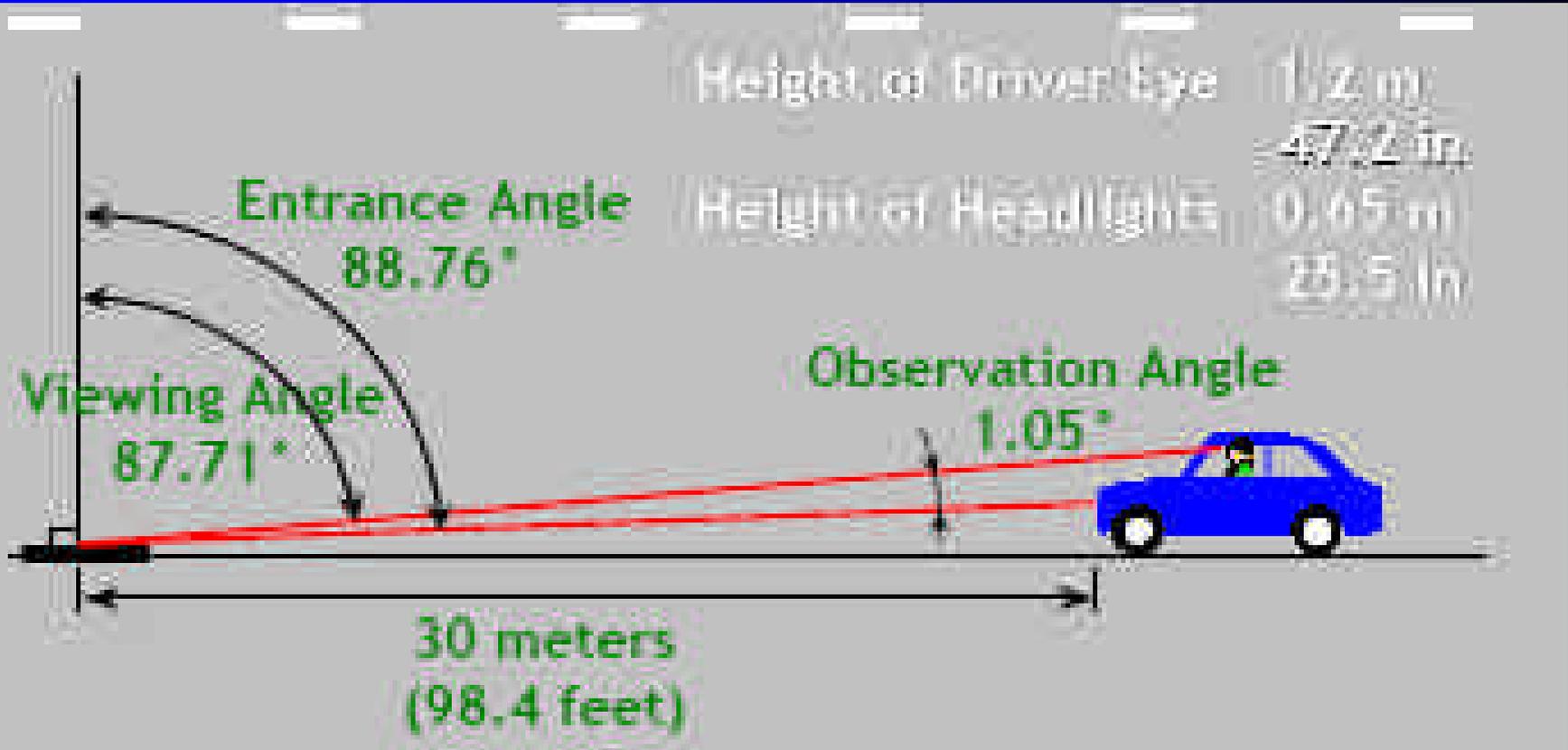
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# Striping Retroreflectivity



# Measuring Retroreflectivity

- 30 meter geometry



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# Measuring Retroreflectivity (cont.)

- Handheld Devices
  - Delta Light & Optics LTL-2000
  - Cost: \$18,000/unit



# Using Hand Held Devices



LTL2000 RETROMETER

DELTA

R1:157 mcd/m<sup>2</sup>/1x  
16:39:57 \*

RL  
TEST

CALIB.  
ZERO

ENTER  
CANCEL

MENU

OFF

2<sup>nd</sup>

PRINT  
FEED

↓

↑

ON

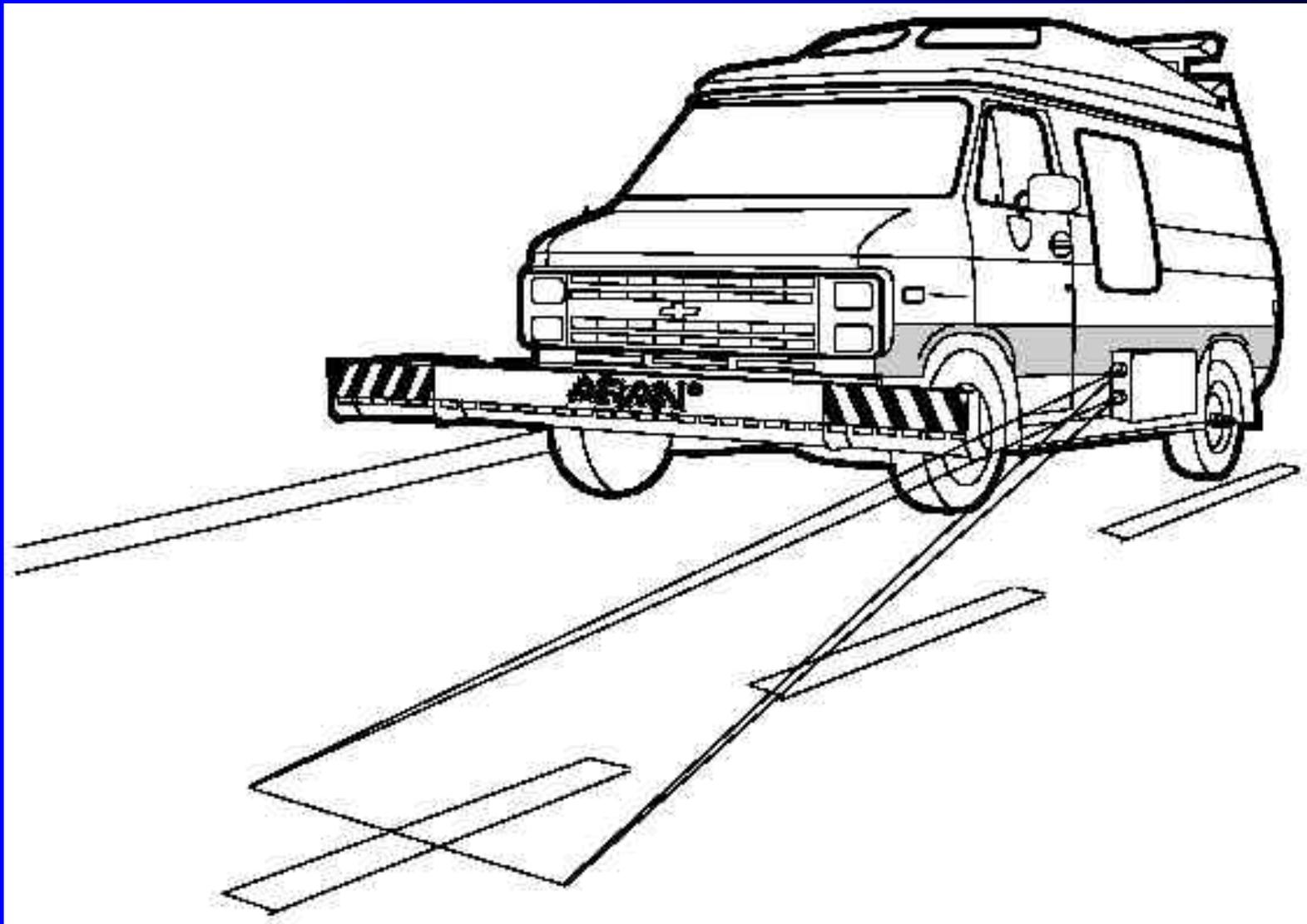
DELTA Light & Optics - Denmark

# Measuring Retroreflectivity (cont.)

- Mobile Devices
  - LaserLux Van
  - Cost: \$150,000+ without van



# Schematic of Scanning Laser



# Laserlux Geometry

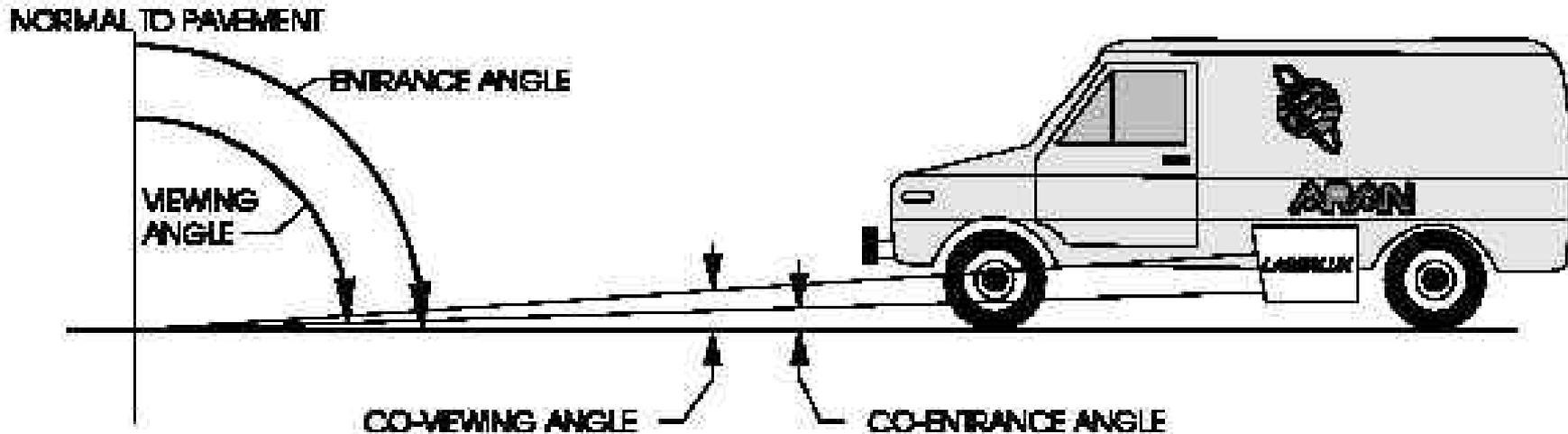
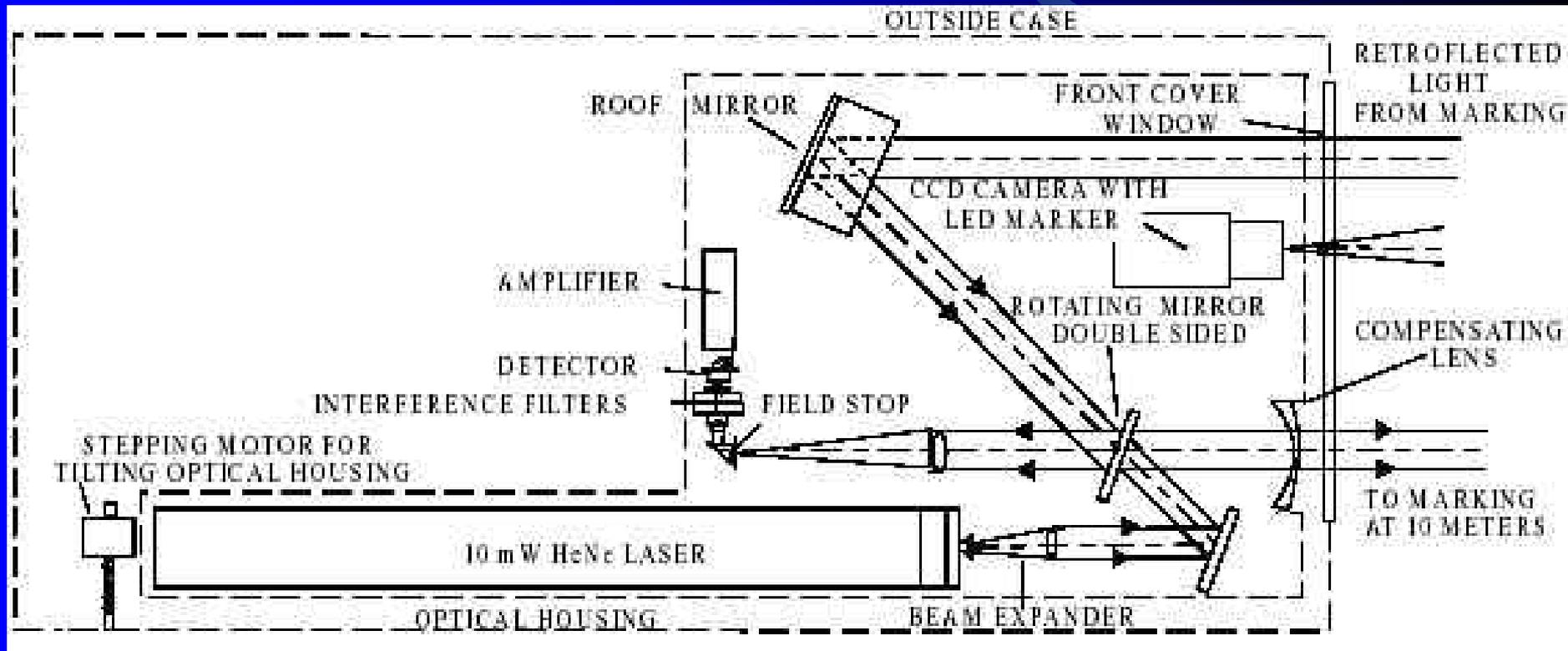


Figure 4. Laserlux geometry. The co-entrance angle can be set at either the Old North American Standard of  $1.5^\circ$ , or the European Committee for Normalization angle of  $1.24^\circ$  (CEN, 1995, ASTM, 1995). The observation angle is fixed at  $1^\circ$ .

# Optical Diagram of the Laserlux Unit



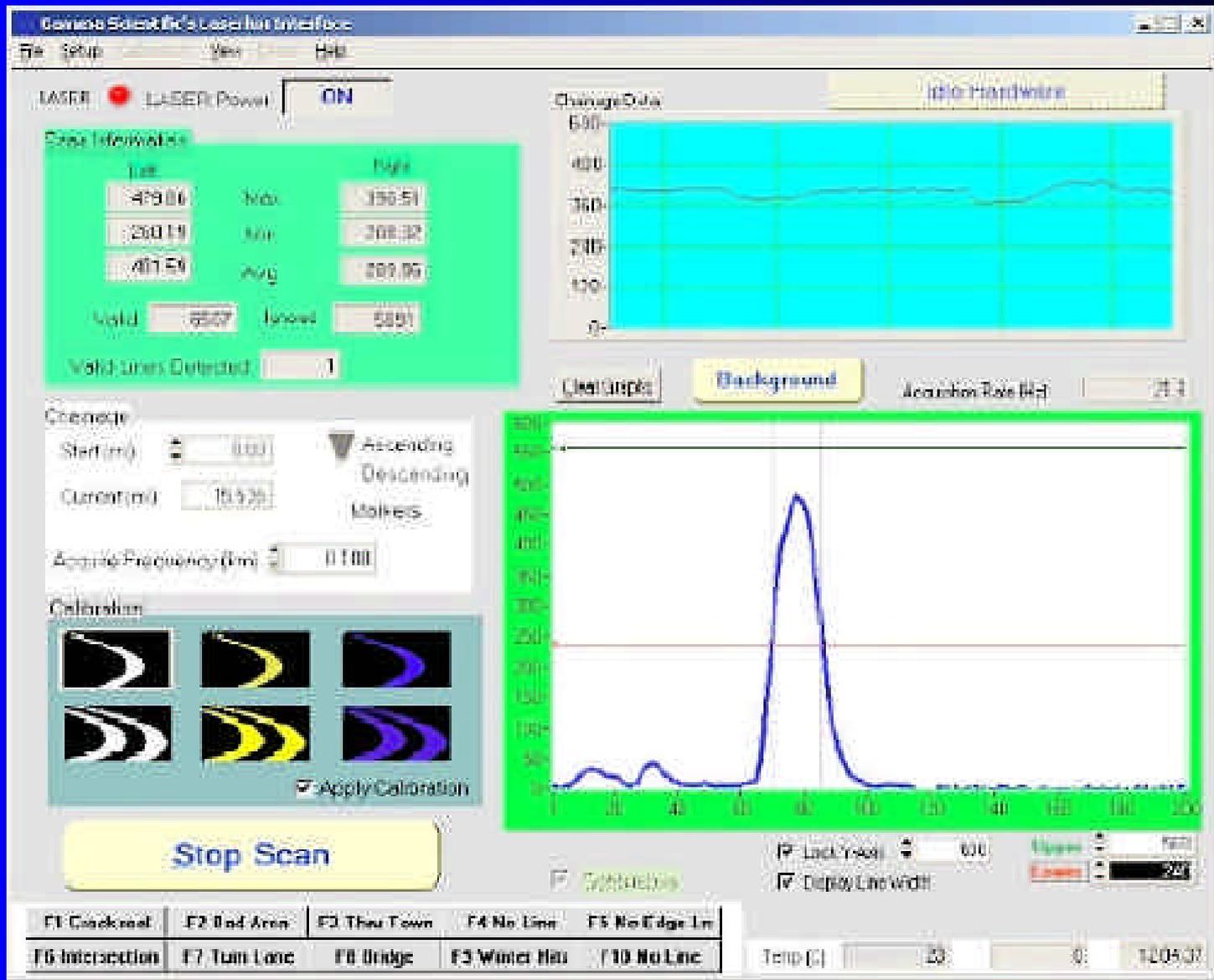
# “Laser eye view” Video



# Laser Operator's Workstation



# Laserlux Software Interface

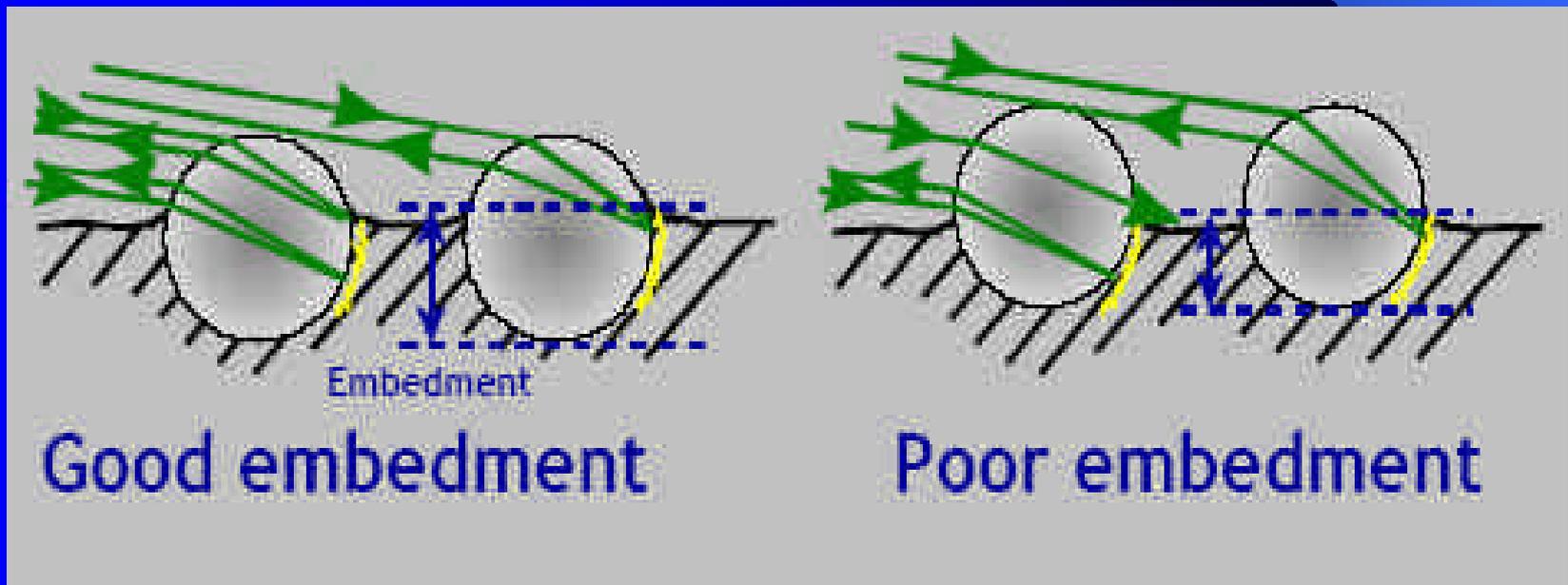


# Optimizing Retroreflectivity

- Factors associated with optimal retroreflectivity:
  - Bead embedment
  - Bead refractive index
  - Bead durability
  - Bead distribution/density
  - Paint durability
  - Paint curing process

# Bead Embedment

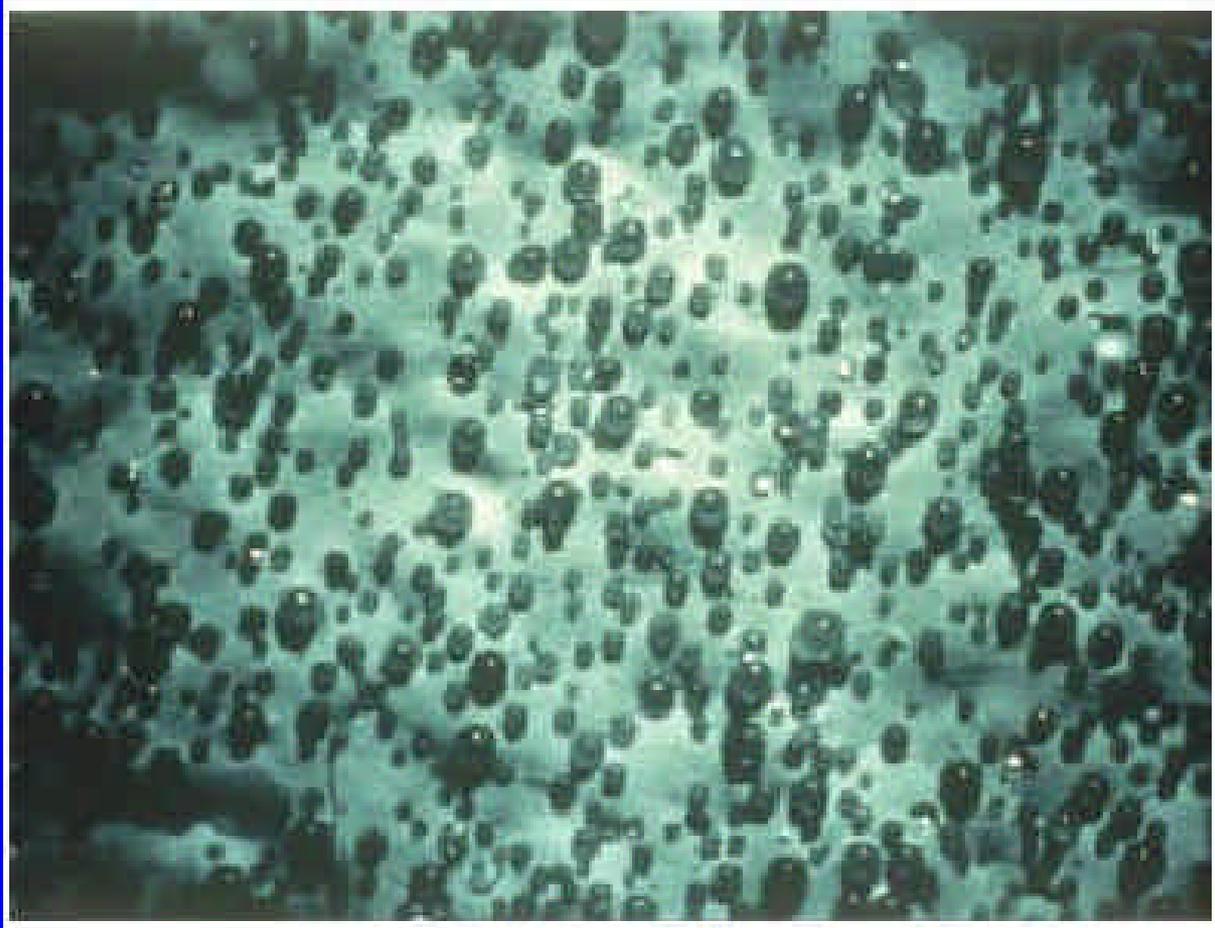
- Affects amount of light entering bead
- Affects durability of marking
- Optimum depth = 50 – 60%
- Bead size and paint thickness affect embedment



# Embedment Problems

- Gradation:
  - Beads too large susceptible to traffic shear
- Paint Thickness
  - 25-30 mil minimum wet thickness
- Paint Viscosity
  - Must allow for beads to embed
- Bead type
  - “Floaters” initially on paint surface
  - “Sinkers” initially immersed within paint

# Poor Bead Embedment



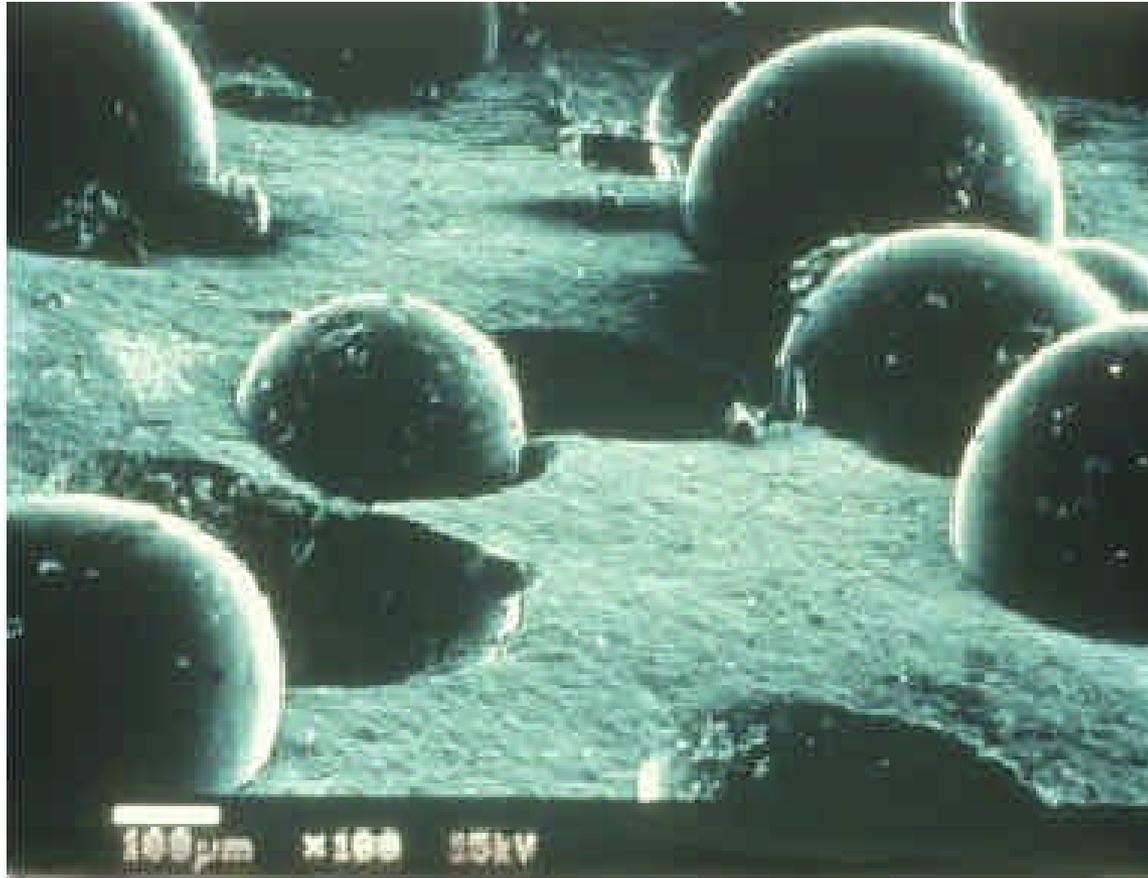
# Paint Thickness & Bead Gradation



**Figure 2.7b**

Magnified view of reflective beads applied to a layer of paint that is too thin

# Paint Thickness & Bead Gradation

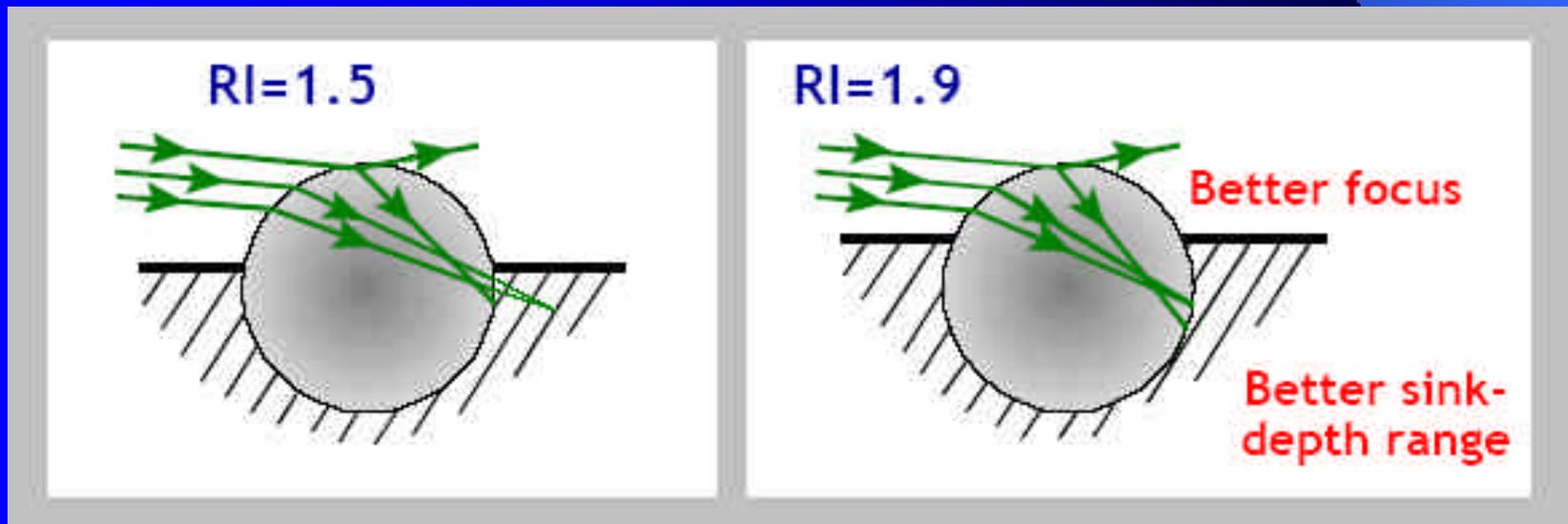


**Figure 2.8**

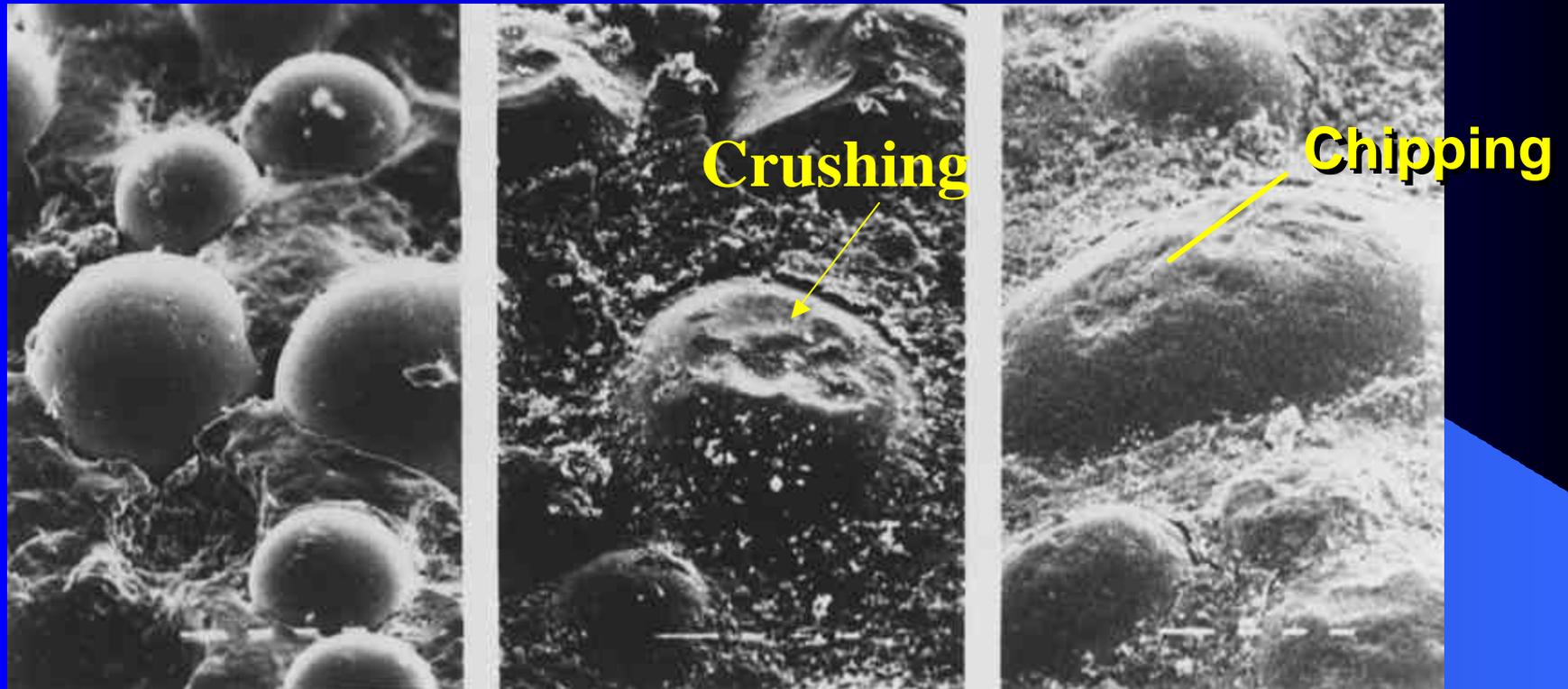
Magnified view of reflective beads at proper embedment depth

# Refractive Index (RI)

- RI impacts performance and durability
- Typically glass: RI 1.5 to 1.9
- Higher RI allows deeper embedment
- Higher RI glass softer – subject to damage



# Bead Durability (from 3M)



Microcrystalline

Ceramic

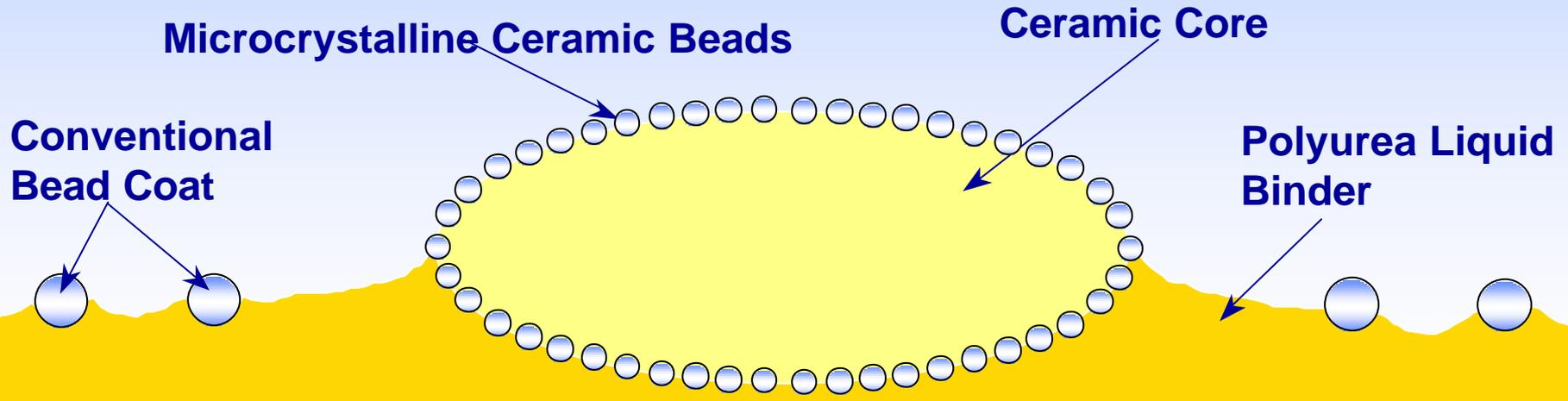
Glass

Glass

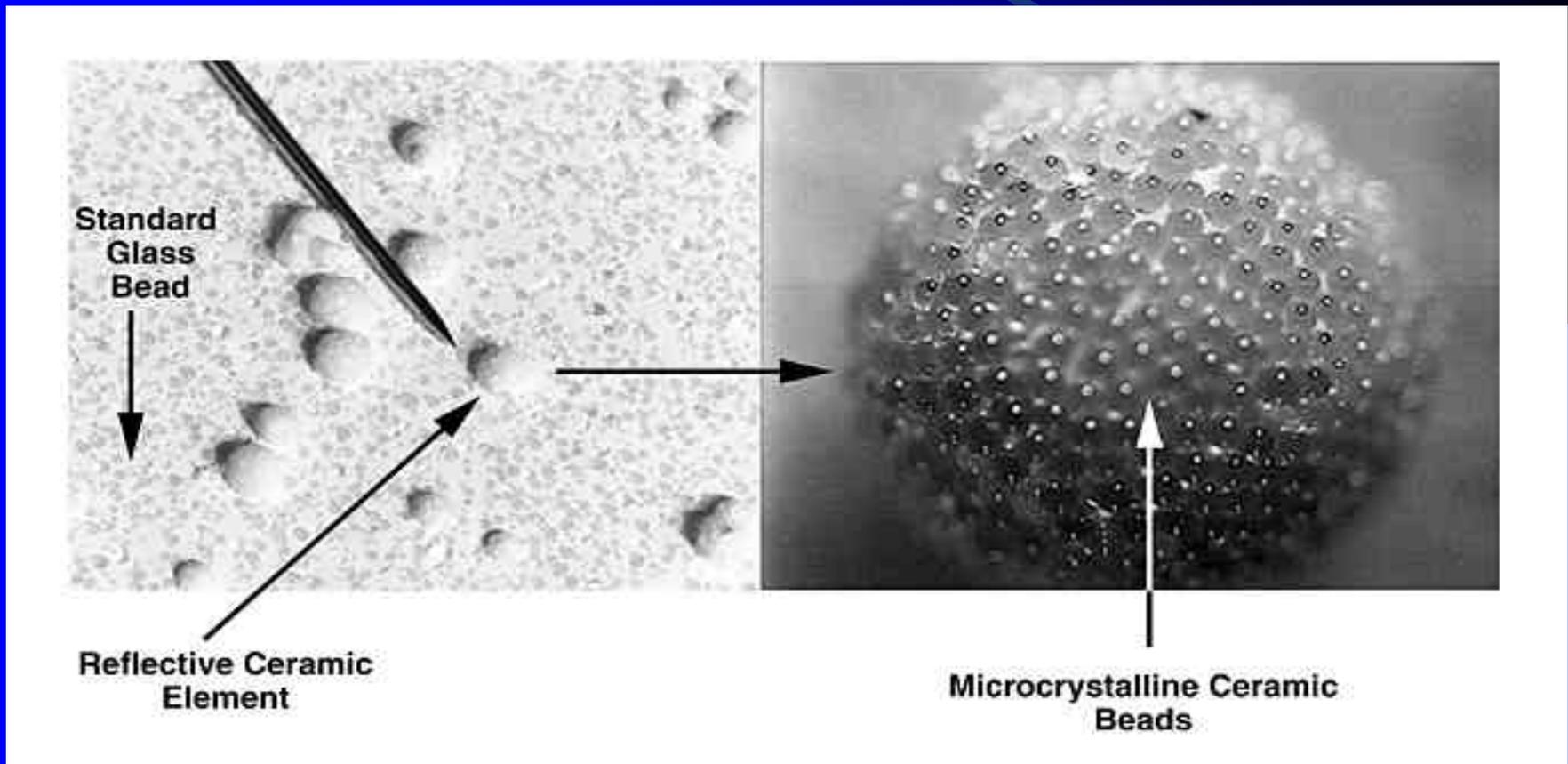
After 24-month Transverse Line Test Deck,  
Las Vegas, Nevada :10,000 ADT

# 3M™ Stamark™ Liquid Pavement Marking Series 1200

## 3M Reflective Element



# 3M Reflective Elements



# Glass and Microcrystalline Beads

## Mechanical Properties (from 3M)

---

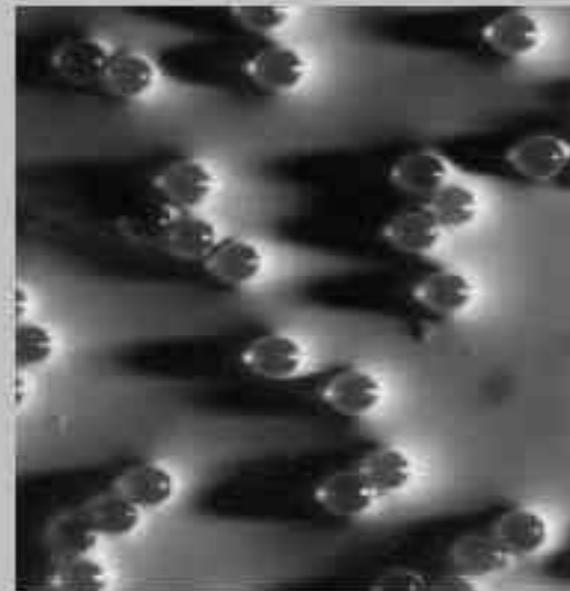
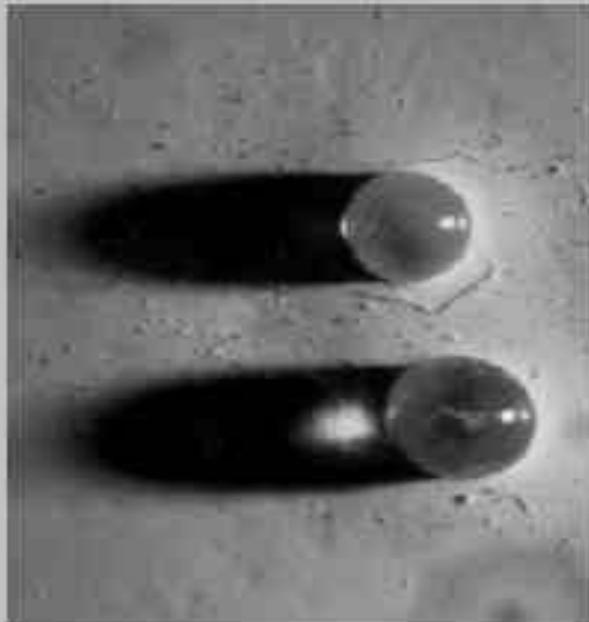
<i>RI</i>	<i>Bead Type</i>	<i>Hardness</i>	<i>Crush Strength</i>
1.5	Glass	650 khn	70-80,000 psi
1.9	Glass	450 khn	30-45,000 psi
	Sand	800 khn	
1.9	Microcrystalline	1,000 khn	> 150,000 psi

---

# Bead Distribution

Poor

Good



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# Pavement Marking Durability in Alaska

- Durability limited by:
  - Snowplows
  - Studded Tires
  - Sanding
- Low application temperature may affect durability
  - Limited curing time

# Pavement Marking Materials

- Durables

- Methyl Methacrylate
- Polyurea (limited AK experience)
- Thermoplastic
- Epoxy (limited AK experience)

- Traffic Paints

- Water-based acrylic (limited AK experience)
- Conventional alkyd
- Low-VOC

# Alaska Test Decks

## Methyl Methacrylate



# Methyl Methacrylate on AK roads

- Problems with color
  - UV Stability? - Lots of variation



# Thermoplastic/Prefformed Tape



# Preformed Tape on Fairbanks Test Deck



# Torch-down Preformed Thermoplastic



# 3M Polyurea – What is it?

- **Two component material. Reaction of an amine with an isocyanate.**
  - **Part A: Amine, pigments, fillers & other ingredients.**
  - **Part B: Isocyanate (cross-linker).**

# Benefits of Polyurea Binder

- Dry-time optimized for reduced motorist impact and operational efficiency...
- Track free in 2-3 minutes
- Cooler temperature application (extends striping season)
- Stays white due to...
  - lower bead loading
  - binder hardness
- UV stability of Polyurea

# 3M Stamark 1200 Polyurea Testing in Fairbanks



# 3M Stamark 1200 Polyurea Testing in Fairbanks

- After one winter season
  - Test deck stripes severely degraded
  - Davis Street stripe retroreflectivity
    - Initial near 1000 mcd/m<sup>2</sup>/lux
    - In Spring - near 100 mcd/m<sup>2</sup>/lux
    - May be due to difficulties during installation

# 3M Stamark 1200 Polyurea Testing in Fairbanks

After one winter season  
on Test Deck



# 3M Stamark 1200 Polyurea

## Testing in Fairbanks

After one winter season on Davis Street



# Water Based Acrylic Testing in Fairbanks

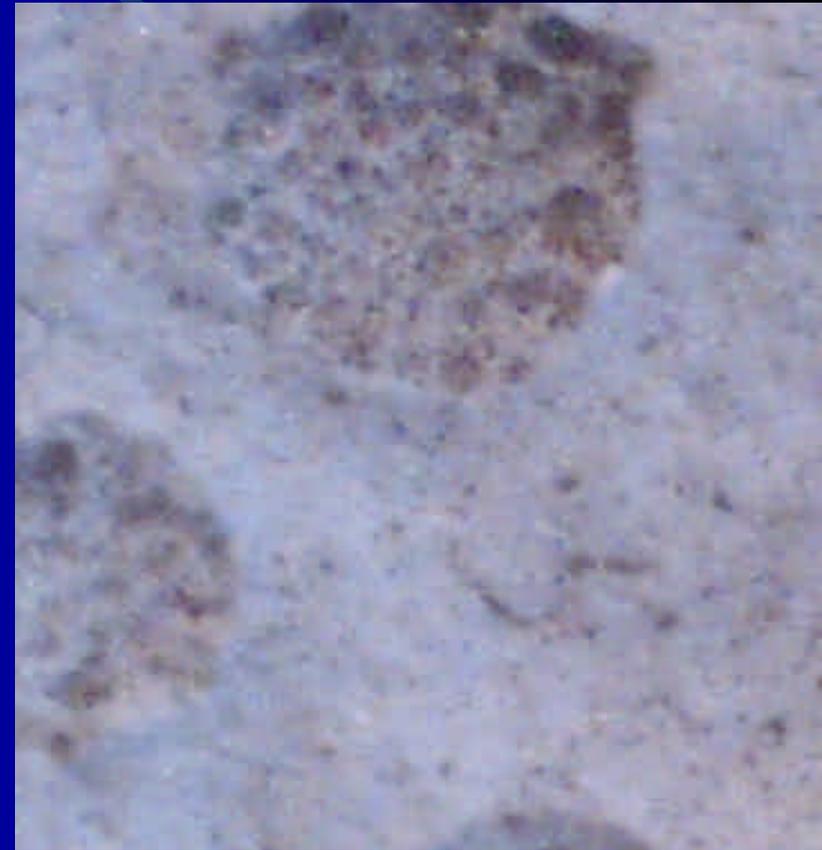
- TMT Pathway ‘Duraline’
  - Durability is promising in comparison to low VOC Paint
  - Cost is only slightly more than standard paint
  - Product color instability likely due to UV

# “Duraline” Water-based Acrylic



# Paint Curing Process

- Low VOC Paint Study



# Specifications

- Performance specification
  - Marking required to meet minimum performance criteria during an initial period after the marking is applied
    - Commonly 0 – 180 days
- Warranty Specification
  - Marking required to meet minimum performance criteria over an extended period of time
    - Commonly 1 – 7 years

# Recommendations for AKDOT&PF

- Develop Performance Specifications
- Appoint a pavement marking coordinator and/or a pavement marking quality improvement team.
  - Lots of expertise in other states
- Develop a pavement marking management system.
  - Performance history
  - Physical hardware/software

# Questions?

